

Progress (in Neuroscience) has often been achieved through the resolution of controversies or “debates”.

Brain versus Heart

Localization versus Holism

Electrical versus Chemical

Fixed versus Plastic

Muscles versus Movements

# Erasistratus influenced Casserio (1600)

Cerebral convulsions not differentiated in any way and look like intestines.

From *Guilo Casserio*

# Pierre Flourens

## 1794-1867

Ablated cortical tissue in animals and showed that the eventual recovery was due to the brain's aggregate field, where the entire brain participated in behaviour.

He was a strong opponent of the localization theory, virtually disproving phrenologists, and advocated a holistic view of the brain, where other parts of the brain could take over the function of damaged ones.

Motor area defined as the lack of movement following a lesion.

## Fritsch & Hitzig (1870)

- 1) First clear experimental demonstration of a region of the cerebral cortex involved in motor function.
- 2) First evidence that the cortex was electrically excitable.
- 3) First experimental evidence of a topographically organized representation of the body in the brain.
- 4) First strong experimental evidence for localization of function in the cerebral cortex.

Motor area defined as those areas when excited give rise to movement.

Motor Cortex has been defined by the methodology employed

## Lesions

(the effect of the missing bits **versus** the function of the remaining bits)

## Anatomy

(motor cortex has been defined as missing layer IV – sensory input?)

## Stimulation

(issue of current spread)

**John Hughlings Jackson**  
**1835-1911**

**How is motor cortex  
organized?**

**Showed how seizures in  
epileptic patients appeared to  
progress from one part of the  
body to the next, apparently  
stimulated from a brain map.**

**This *topographic* organization  
theory helped swing the  
pendulum back toward the  
localizationist view.**

Using electrical stimulation as a tool to determine the functional organization of motor cortex

The early studies and the emergence of the debate of “muscles” versus “movements”.

Fritsch and Hitzig versus Ferrier

**Beevor and Horsley**

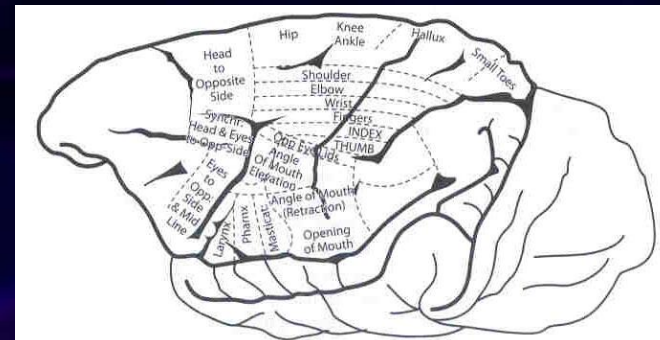


Figure 2-3 The map of stimulation-evoked movements in the monkey brain from Beevor and Horsley (1890).

Thomas Kuhn

A discipline becomes a science when it crystallizes around a paradigm (methodology).

Using electrical stimulation as a tool to determine the functional organization of motor cortex

The later studies (short-trains)

Sherrington

Penfield

Asunuma



# Sherrington

1857-1952

He noted that prior stimulation of one site could alter the movement at another site.

Even though he was using short bursts of stimulation he reached the important conclusion that the map was not anatomically fixed but plastic and dependent on its activation history.

That is to say the motor cortex is the repository of a large variety of sequences of movements

# Penfield 1950

Mrs H.P. Cantlie

Mistakes,  
Errors,  
& a  
Misrepresentation

# Penfield's Seven Major Contributions;

- 1) Size of the study and the meticulous manner made it an instant classic!
- 2) Movements and sensations were partially overlapping but mostly separate thus establishing the distinction between motor and somatosensory cortex (???).
- 3) Argued against the view of a roster of perfectly separated body parts (**contra Mrs H.P. Cantlie's rendering**), **they are fuzzy**.
- 4) Rejected the division between primary and premotor cortex (**too extreme**).
- 5) Defined a supplementary motor area more medially located.
- 6) (**Re**)introduction of the term homunculus, "little human".
- 7) He is credited for discovering the motor map (**he didn't**).

## Beyond surface mapping

Hiroshi Asanuma (1927-2000)

In the late 60's, Asanuma developed the technique of intracortical microstimulation and used it to dissect how the primary motor cortex controls individual muscle contractions to generate skilled movements.

Using electrical stimulation as a tool to determine the functional organization of motor cortex

The pendulum swings...

Graziano

## Graziano, 2000s

He evoked complex, coordinated movements involving multiple joints in monkeys.

The train duration used was similar to both the timescale of forelimb reaches and motor cortex neuron activity during movement in monkeys.

It appears that train duration is a critical factor mediating evoked movements by ICMS.

At behaviourally relevant time-scales, complex movements similar to spontaneous behaviour are evoked.



# Summary



No one gets it all right.

The muscles versus movement “debate” is entangled in the localization of function “debate”.

It seems that are highly specialized areas of complex “purposeful” movements

This is “why” brain injury survivors show compensation rather than recovery.

What have been the historical changes in our thinking?

The motor cortex is  
excitable,  
plastic,  
highly differentiated (specialized)  
interconnected with other structures  
mislabelled (not labelled correctly or functionally)  
  
twice as large